

# Basic Radio Propagation Predictions

FOR SEPTEMBER 1958

Three Months in Advance

Issued June 1958

CRPL Series D



Number 166

## The Central Radio Propagation Laboratory

The propagation of radio waves over long distances depends on their reflection from the ionosphere, the electrically conducting layers in the earth's upper atmosphere. The characteristics of these layers are continually changing. For regular and reliable communication, it is therefore necessary to collect and analyze ionospheric data from stations all over the world in order that predictions of usable frequencies between any two places at any hour can be made. During the war, the United States Joint Communications Board set up the Interservice Radio Propagation Laboratory at the National Bureau of Standards to centralize ionospheric work and predictions for the Armed Forces of the United States.

On May 1, 1946, this activity returned to peacetime status as the Central Radio Propagation Laboratory of the National Bureau of Standards. Designed to act as a permanent centralizing agency for propagation predictions and studies, analogous in the field of radio to the reports of the Weather Bureau in the field of meteorology, the Central Radio Propagation Laboratory was established in cooperation with the many Government agencies vitally concerned with communication and radio propagation problems. These agencies are represented on an Interdepartmental Council on Radio Propagation and Standards which assists in furthering the work of the Laboratory; included are the Departments of State, Army, Navy, and Air Force, United States Information Agency, United States Coast Guard, Civil Aeronautics Administration, and Federal Communications Commission. Observers have been designated by the Air Navigation Development Board, Interdepartment Radio Advisory Committee, United States Coast and Geodetic Survey, and United States Weather Bureau. The Council works in cooperation with a Technical Advisory Committee appointed by the Institute of Radio Engineers at the request of the Director, National Bureau of Standards.

The Central Radio Propagation Laboratory receives and analyzes data from approximately 120 stations located throughout the world, including 8 domestic and 17 overseas stations which are operated either directly or under contract by the National Bureau of Standards. Ionospheric data and predictions are disseminated to the Armed Forces, commercial users, scientists, and laboratories. The basic ionospheric research of the Laboratory includes theoretical and experimental studies of maximum usable frequencies, ionospheric absorption, long-time variations of radio propagation characteristics, the effects of the sun on radio propagation, and the relation between radio disturbance and geomagnetic variation. In the microwave field, the Laboratory is investigating the relation between radio propagation and weather phenomena, as well as methods by which predictions can be made and radio communications improved in this portion of the radio-frequency spectrum. Another phase of the Laboratory's work is the development and maintenance of standards and methods of measurement of many basic electrical quantities throughout the entire frequency spectrum.

### Basic Radio Propagation Predictions

The CRPL Series D, Basic Radio Propagation Predictions, is issued monthly as an aid in the determination of the best sky-wave frequencies over any path at any time of day for average conditions for the month of prediction, 3 months in advance. Charts of extraordinary-wave critical frequency for the  $F_2$  layer, of maximum usable frequency for a transmission distance of 4,000 km, and of percentage of time occurrence for transmission by sporadic  $E$  in excess of 15 Mc, for a distance of 2,000 km, are included.

Beginning with the January 1956 issue (CRPL-D137) the CRPL-D series, "Basic Radio Propagation Predictions," is available on a purchase basis from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., on the following terms:

Single Copy .....	10 cents
Annual subscription (12 issues) .....	\$1.00
(To foreign countries, \$1.25)	

The rules of the Superintendent of Documents require that remittances be made in advance either by coupons sold in sets of 20 for \$1 and good until used, or by check or money order payable to the Superintendent of Documents. Currency, if used, is at Sender's risk. Postage stamps, foreign money, and defaced or smooth coins are not acceptable. Remittances from foreign countries should be by international money order payable to the Superintendent of Documents or by draft on a United States bank.

Address subscriptions, remittances, and all inquiries relating thereto, to the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

The printing of this publication has been approved by the Director of the Bureau of the Budget, July 20, 1955.



# BASIC RADIO PROPAGATION PREDICTIONS

## FOR SEPTEMBER 1958

## THREE MONTHS IN ADVANCE

### Introduction

The CRPL-D series, "Basic Radio Propagation Predictions," issued by the National Bureau of Standards, contains contour charts of monthly median  $F^2$ -zero-MUF and  $F^2$ -4000-MUF for each of the three zones, W, I, and E, into which the world is divided for the purpose of taking into consideration the variation of the characteristics of the  $F^2$  layer with longitude (figs. 1 to 6); the worldwide contour chart of monthly median  $E$ -2000-MUF (fig. 7); the contour chart of median  $fEs$  (fig. 8); and the chart showing percentage of time occurrence for  $Es$ -2000-MUF in excess of 15 Mc (fig. 9).

Methods for using these charts are given in Circular 465 of the National Bureau of Standards, entitled "Instructions for the Use of Basic Radio Propagation Predictions," and available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., price 30 cents (to foreign countries, 40 cents). Requests for this manual and for the basic predictions from members of the Army, Navy, or Air Force should be sent to the proper service address as follows. *For the Army:* Office of the Chief Signal Officer, Department of the Army, Washington 25, D. C., Attention: SIGOL-2. *For the Navy:* The Director, Naval Communications. *For the Air Force:* Director of Communications, Department of the Air Force, Washington 25, D. C., Attention: AFOAP.

Following figure 9 of each issue, sets of auxiliary figures (nos. 1, 2, 11, 12 of NBS Circular 465) or forms CRPL-AF and AH are given in rotation, two in each issue of CRPL Series D. They are necessary or useful for the preparation of tables and graphs of MUF and FOT (OWF), as explained in NBS Circular 465.

The charts in this issue were constructed from data through March 1958, together with the smoothed 12-month running-average Zürich sunspot number 150, centered on September 1958. The mean number for the year 1957 was 190.

Attention is invited to the blank form at the end of this publication, for use in reporting the accuracy of the predictions of MUF and FOT (OWF) as given in this report. Communications should be addressed to Central Radio Propagation Laboratory, National Bureau of Standards, Boulder, Colorado. Please note this is not an address for subscriptions. These are given elsewhere in this report.

Information concerning the theory of radio-wave propagation, measurement technics, structure of the ionosphere, ionospheric variations, prediction methods, absorption, field intensity, radio noise, lowest required radiated power, and lowest useful high frequency is given in Circular 462 of the National Bureau of Standards, "Ionospheric Radio Propagation." This circular is available from the Superintendent of Documents, price \$1.25 (to foreign countries, \$1.65). Additional information about radio noise may be found in NBS Circular 557, "Worldwide and Radio Noise Levels Expected in the Frequency Band 10 Kilocycles to 100 Megacycles," also available from the Superintendent of Documents, price 30 cents (to foreign countries, 40 cents) and in C.C.I.R. Report No. 65, "Revision of Atmospheric Radio Noise Data," International Telecommunication Union, Geneva, 1957.



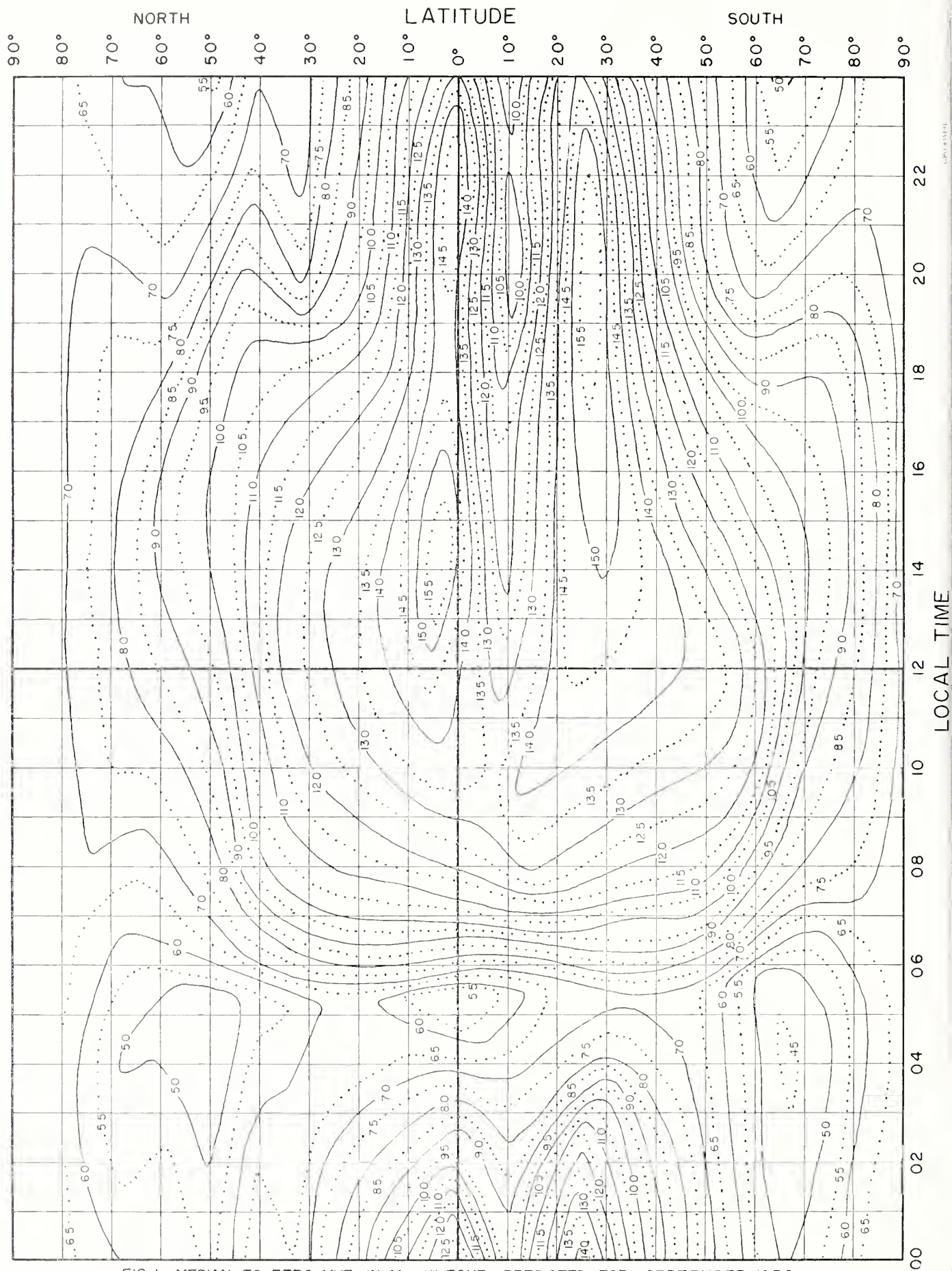


FIG 1. MEDIAN F2-ZERO-MUF, IN Mc, W ZONE, PREDICTED FOR SEPTEMBER 1958

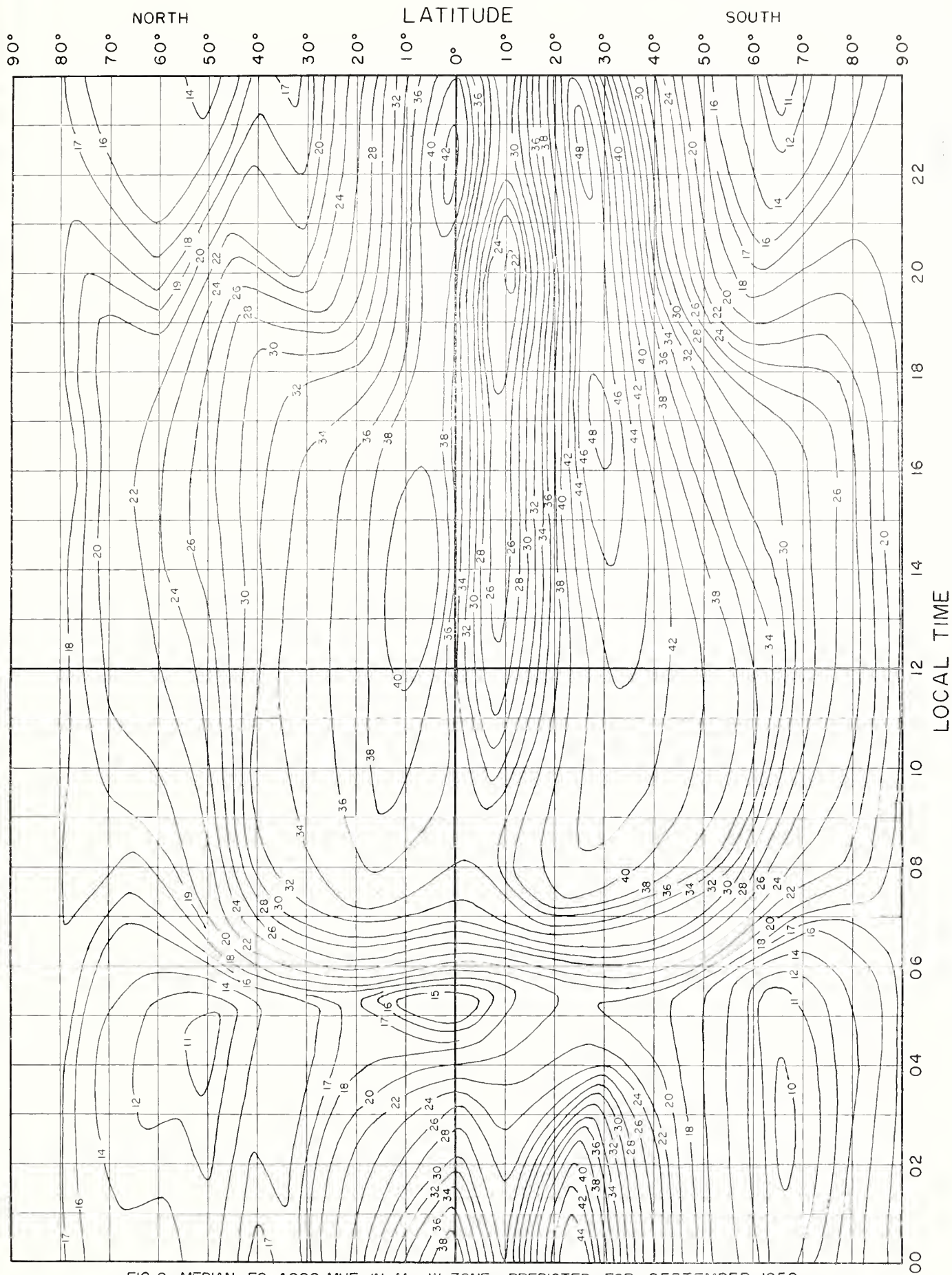


FIG 2 MEDIAN F2-4000-MUF, IN Mc, W ZONE, PREDICTED FOR SEPTEMBER 1958



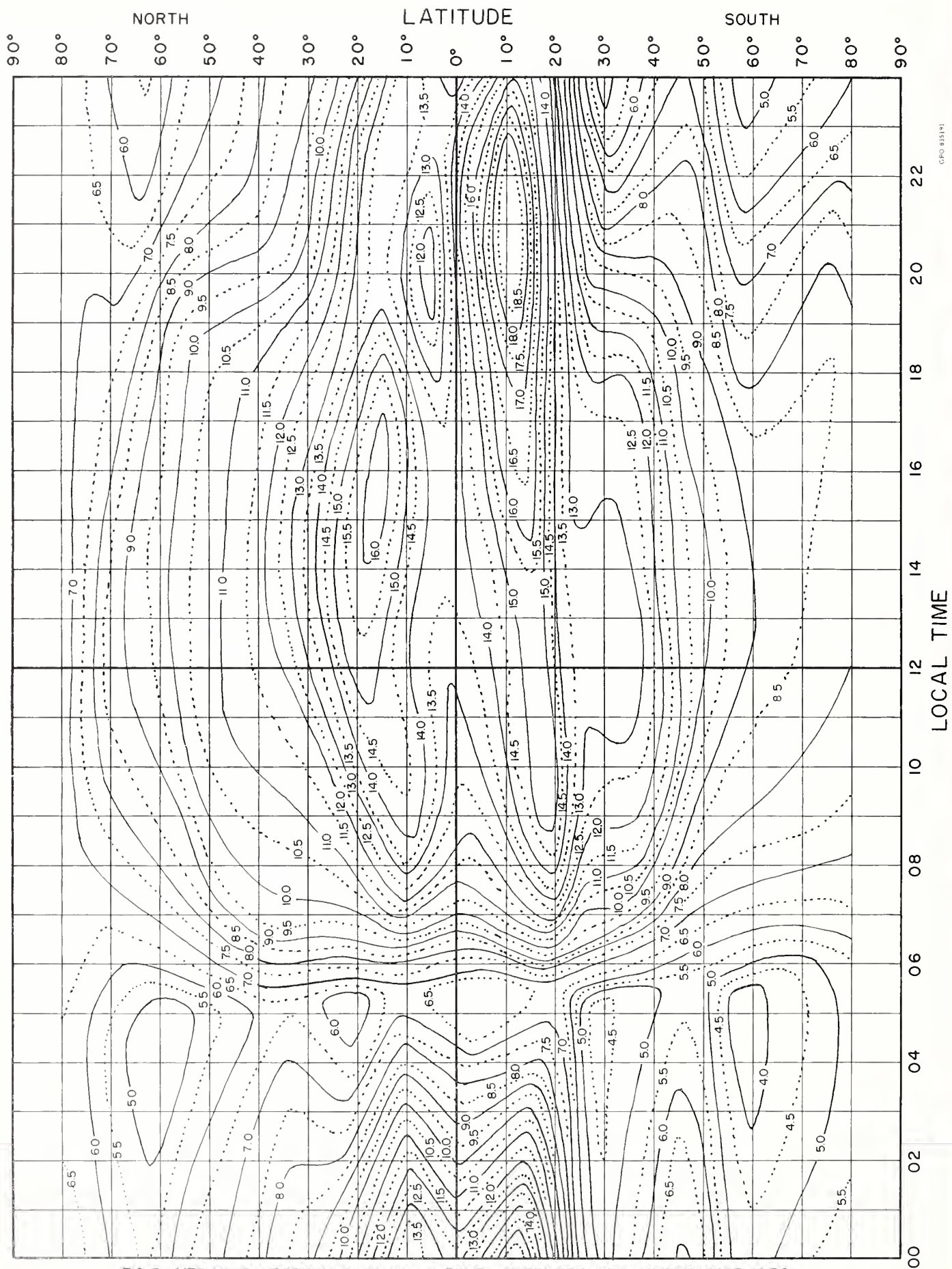


FIG. 3. MEDIAN F2-ZERO-MUF, IN Mc, I ZONE, PREDICTED FOR SEPTEMBER 1958

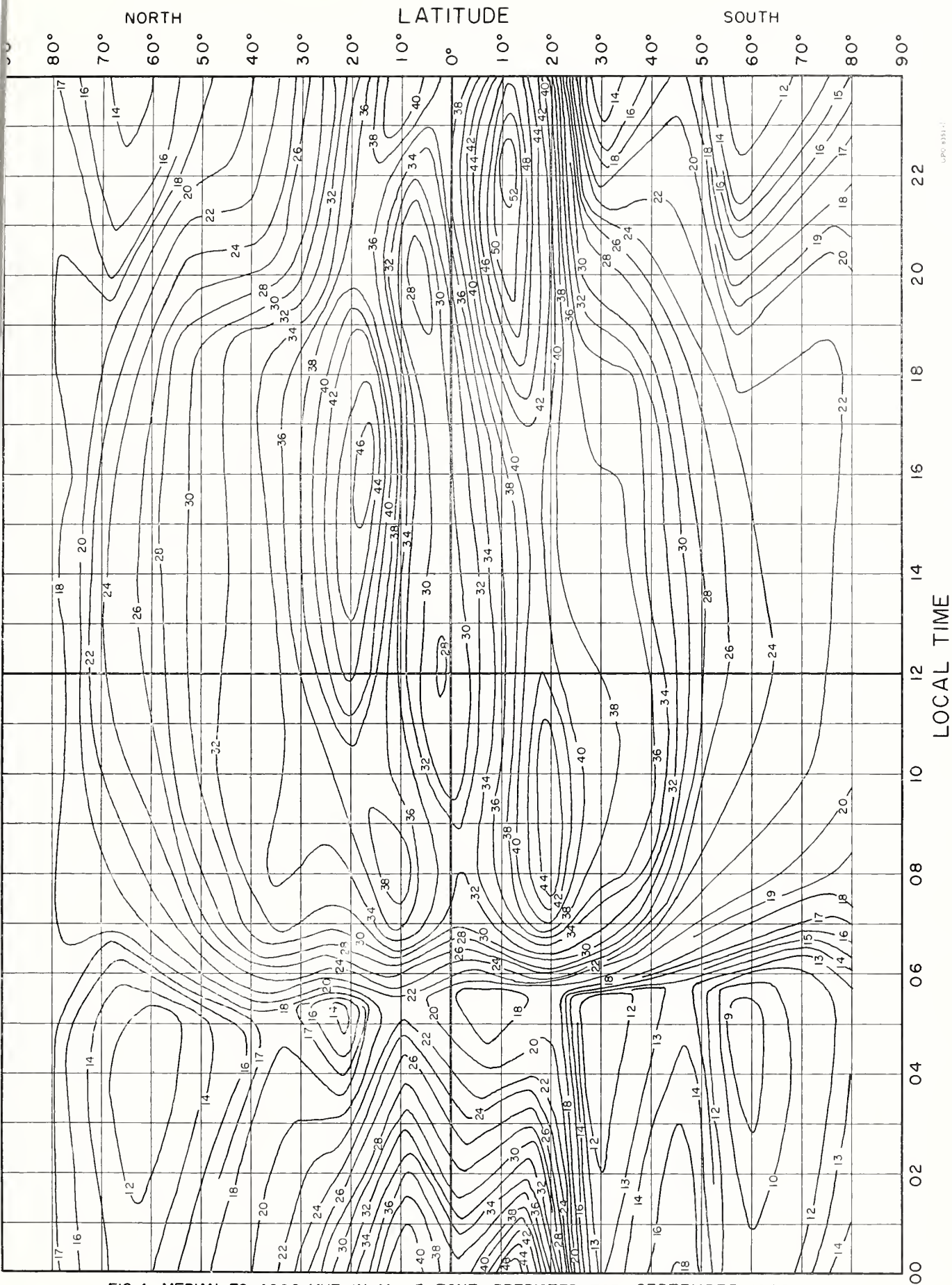


FIG. 4. MEDIAN F2-4000-MUF, IN Mc, I ZONE, PREDICTED FOR SEPTEMBER 1958

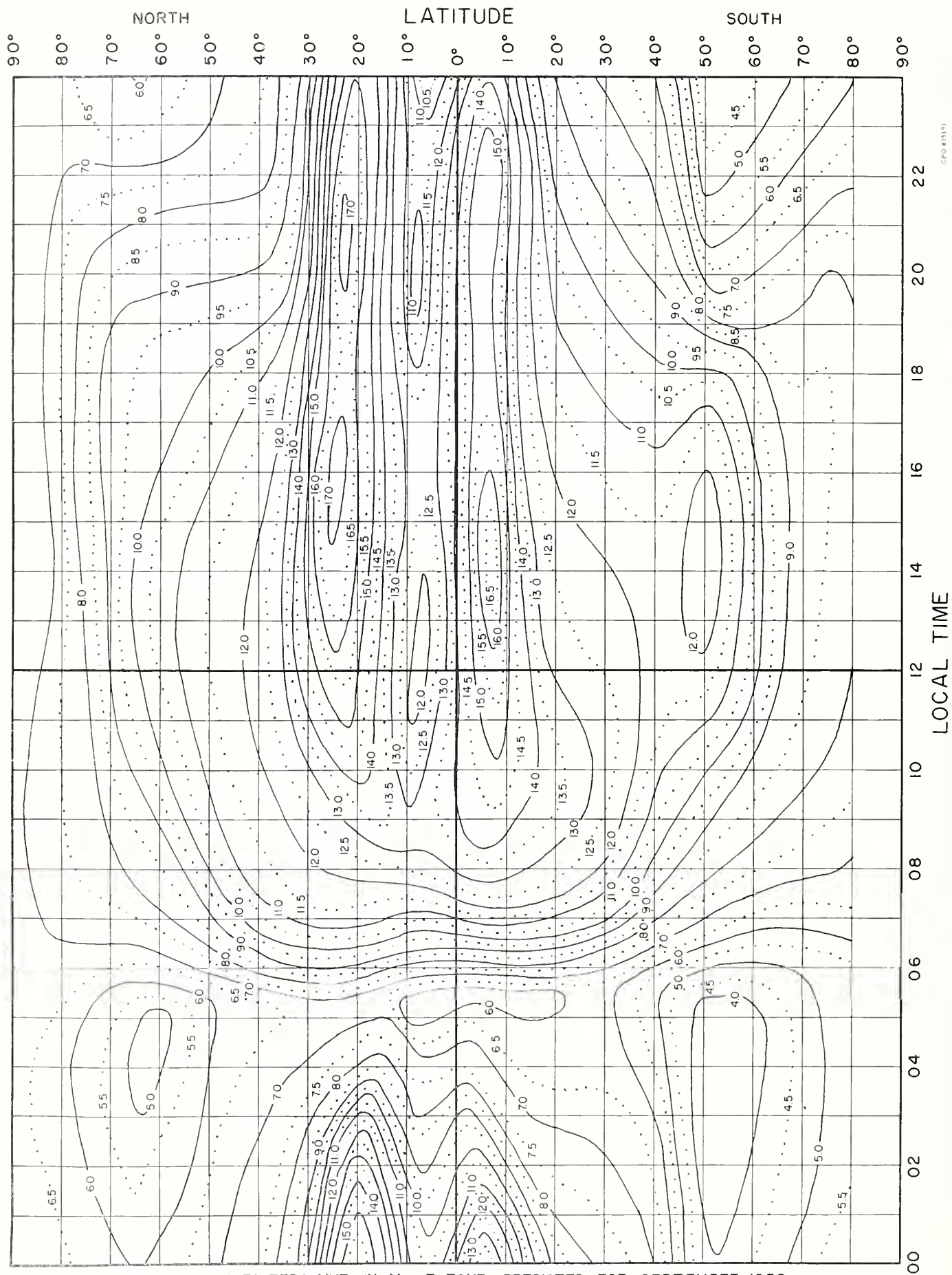


FIG 5. MEDIAN F2-ZERO-MUF, IN Mc, E ZONE, PREDICTED FOR SEPTEMBER 1958



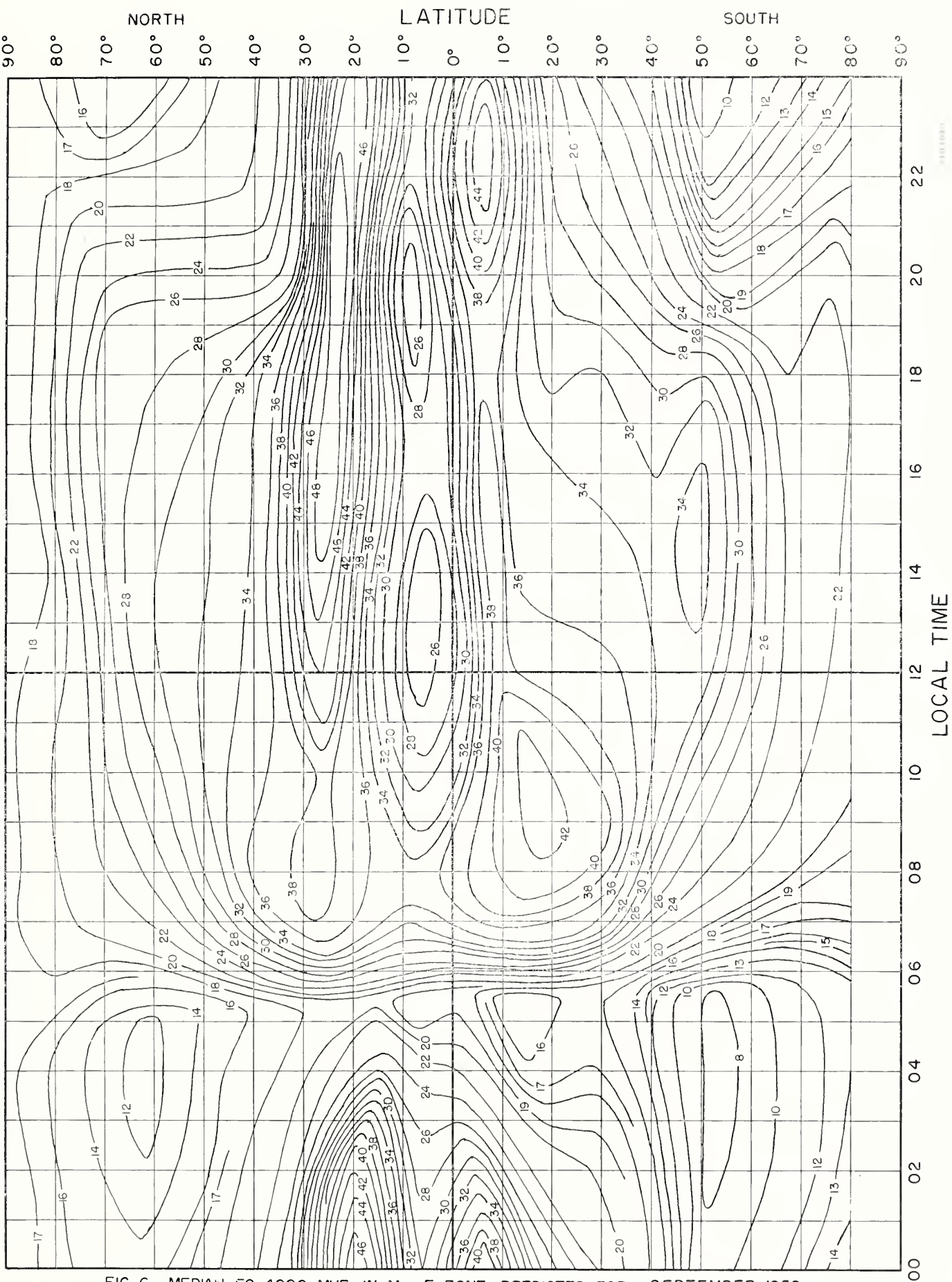


FIG. 6. MEDIAN F2-4000-MUF, IN Mc, E ZONE, PREDICTED FOR SEPTEMBER 1958

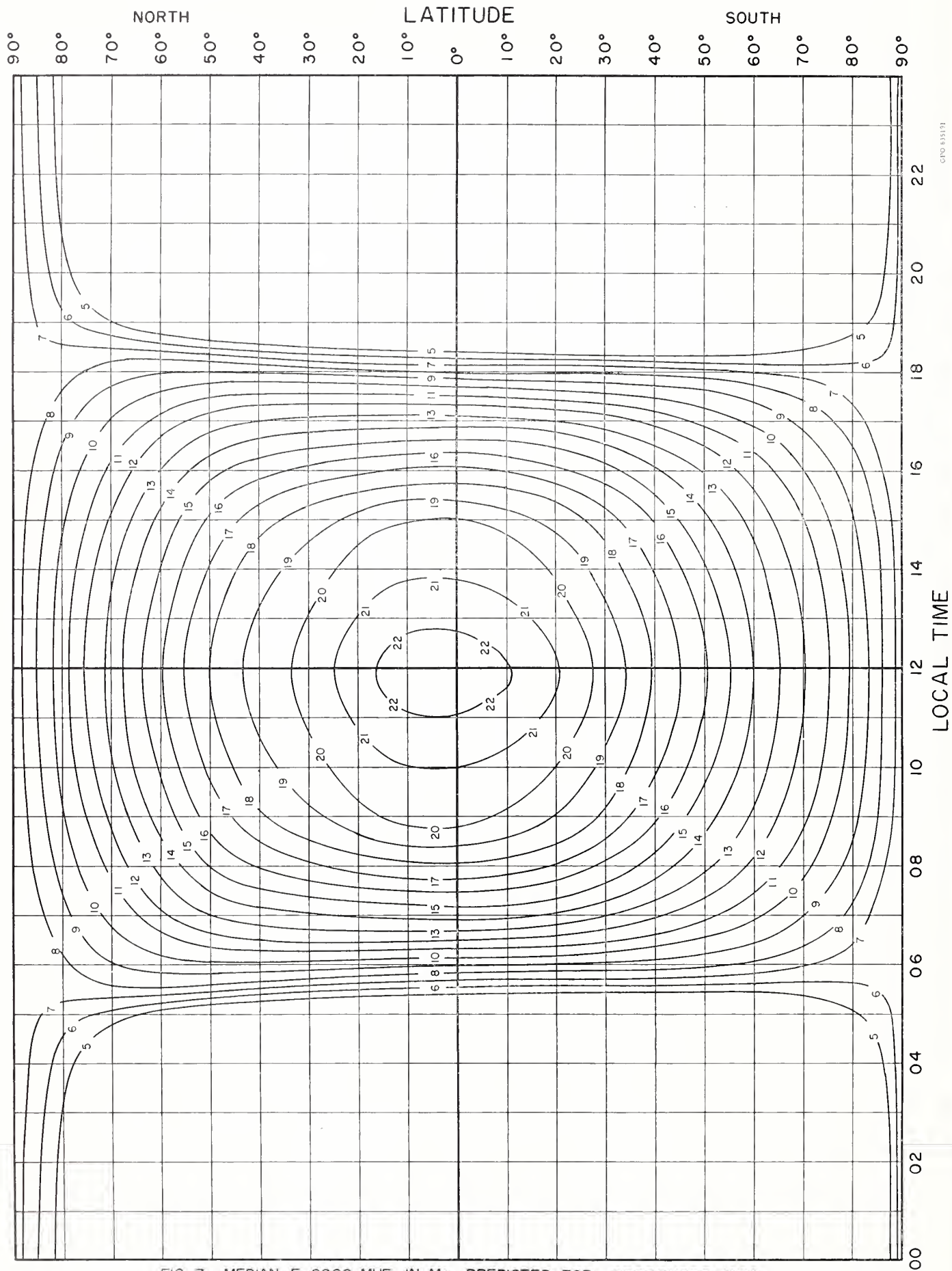


FIG. 7. MEDIAN E-2000-MUF, IN Mc, PREDICTED FOR SEPTEMBER 1958

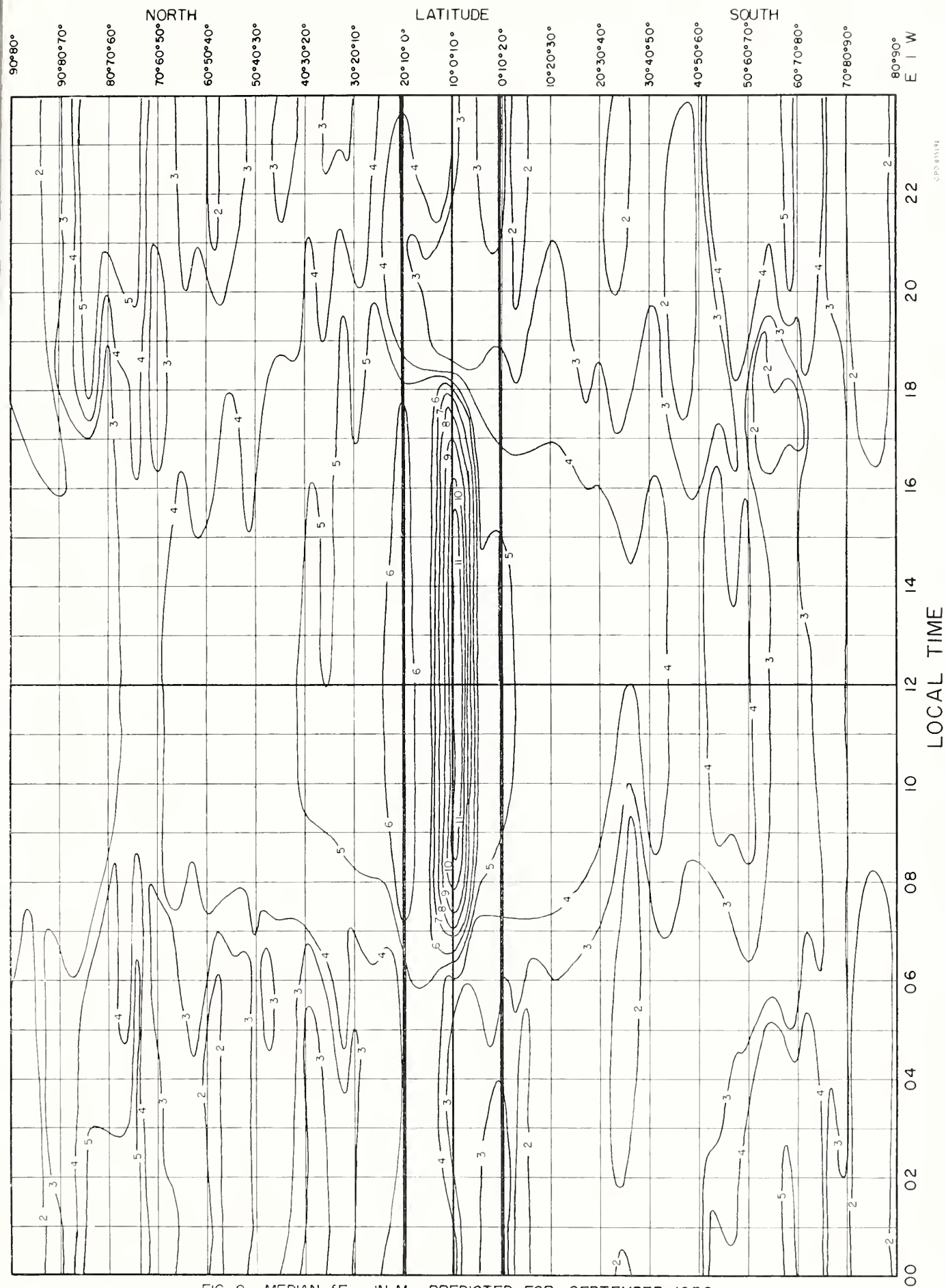


FIG. 8. MEDIAN fEs, IN Mc, PREDICTED FOR SEPTEMBER 1958



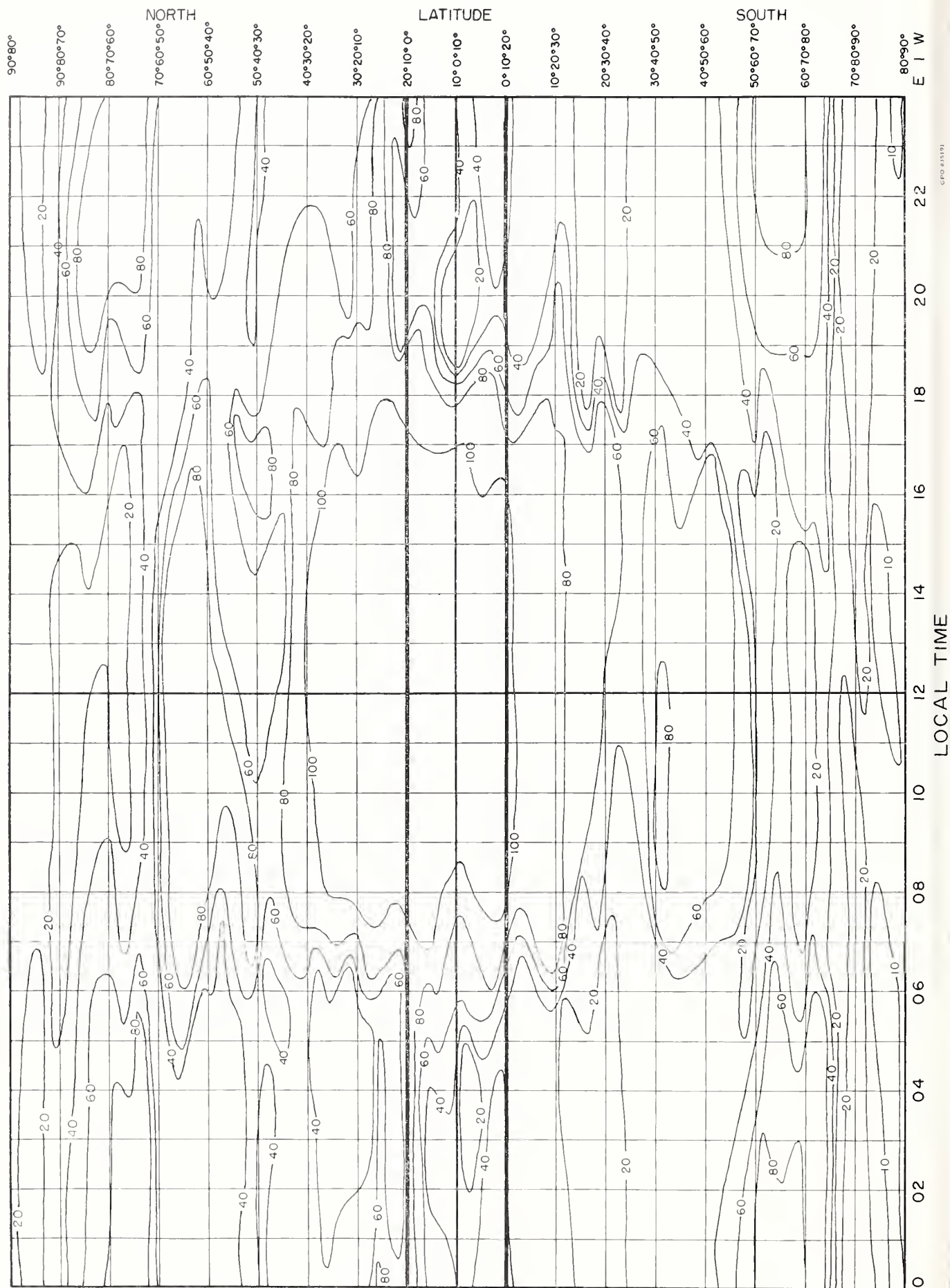


FIG. 9. PERCENTAGE OF TIME OCCURRENCE FOR Es-2000-MUF IN EXCESS OF 15 Mc, PREDICTED FOR SEPTEMBER 1958

## MUF - FOT WORK SHEET FOR PATHS 4000 KM OR LESS

From \_\_\_\_\_ To \_\_\_\_\_ Distance, \_\_\_\_\_ km Zone \_\_\_\_\_ Predicted for \_\_\_\_\_ 19 \_\_\_\_\_

Note: All frequencies are in megacycles.

GCT	fEs		Es 2000-muf		E-layer 2000-muf	F2 zero-muf	F2 4000-muf	Es -muf for Path	E-F1-muf for Path	F2-muf for Path	Es 2000-fot	Es -fot for Path	E -fot for Path	F2 - fot for Path	MUF for Path	FOT for Path
	a	b	5 X o	c												
Procedure	Scale			Scale	Scale	Scale	Scale				b-4.0		Same as g	.85h	Highest of f <sub>i,g,h</sub>	Highest of f <sub>j,k,l</sub>
00																
01																
02																
03																
04																
05																
06																
07																
08																
09																
10																
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22																
23																
Done by																
Checked																

NOTE: FOT IS THE SYMBOL FOR OPTIMUM TRAFFIC FREQUENCY (FORMERLY OMF)

CRPL

MUF - FOT WORK SHEET FOR PATHS OVER 4000 KM.

**Note: All frequencies are in megacycles**

[illegible]

NOTE FOT IS THE SYMBOL FOR OPTIMUM TRAFFIC FREQUENCY (FORMERLY OWF)





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## CRPL Reports

[A detailed list of CRPL publications is available from the Central Radio Propagation Laboratory upon request]

*Daily:*

Radio disturbance forecasts, every half hour from broadcast stations WWV and WWVH of the National Bureau of Standards.

Telephoned and telegraphed reports of ionospheric, solar, geomagnetic, and radio propagation data.

*Semiweekly:*

CRPL—J. North Atlantic Radio Propagation Forecast (of days most likely to be disturbed during following month).

CRPL—Jp. North Pacific Radio Propagation Forecast (of days most likely to be disturbed during following month).

*Semimonthly:*

CRPL—Ja. Semimonthly Frequency Revision Factors For CRPL Basic Radio Propagation Prediction Reports.

*Monthly:*

CRPL—D. Basic Radio Propagation Predictions—Three months in advance. (Dept. of the Army, TB 11-499-, monthly supplements to TM 11-499; Dept. of the Air Force, TO 31-3-28 series). On sale by Superintendent of Documents.\* Members of the Armed Forces should address cognizant military office.

CRPL—F. (Part A). Ionospheric Data.

(Part B). Solar-Geophysical Data.

Limited distribution. These publications are in general disseminated only to those individuals or scientific organizations which collaborate in the exchange of ionospheric, solar, geomagnetic or other radio propagation data.

*Catalog of Data:*

A catalog of records and data on file at the U.S. IGY World Data Center A for Airglow and Ionosphere, Boulder Laboratories, National Bureau of Standards, which includes a fee schedule to cover the cost of supplying copies, is available upon request.

The publications listed above may be obtained without charge from the Central Radio Propagation Laboratory, National Bureau of Standards, Boulder Laboratories, Boulder, Colorado, unless otherwise indicated. Please note that the F series is not generally available.

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*Circulars of the National Bureau of Standards pertaining to Radio Sky Wave Transmission:*

NBS Circular 462. Ionospheric Radio Propagation. \$1.25.

NBS Circular 465. Instructions for the Use of Basic Radio Propagation Predictions. 30 cents.

NBS Circular 557. Worldwide Radio Noise Levels Expected in the Frequency Band 10 Kilocycles to 100 Megacycles. 30 cents.

NBS Circular 582. Worldwide Occurrence of Sporadic E. \$3.25.

These Circulars are on sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Members of the Armed Forces should address the respective military office having cognizance of radio wave propagation.

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\* For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D. C. Price 10 cents (single copy). Subscription Price: \$1.00 a year; 25 cents additional for foreign mailing.